Leveraging Command And Control Technology To Provide Advanced Environmental Effects Decision Aids On The Battlefield

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Abstract

Computer and communication technology has been advancing within the military command and control (C2) systems since the advent of the modern computer. A number of existing or evolving C2 systems within the United State's Department of Defense leverage this technology to provide automated environmental effects decision aids to the tactical user (e.g., the Army Battle Command System, the Air Force Theater Battle Management Core System and the Navy Integrated Tactical Environmental Subsystem). These C2 systems have advanced noticeably from the first systems that were primarily stand alone, or stove pipe, workstations that did not share information between the various battlefield functional areas, much less between the services. Although great strides have been made in the 1990's to integrate these cross functional applications, emerging technology will allow for even more advances, to include: autonomous intelligent agents; more fully integrated software modules; cross service common applications; and the development of common displays and databases both within and across the services. This paper will examine in more detail the current status of this environmental effects software (from primarily an Army perspective) and will discuss new applications that will leverage ongoing advances in computer and communication technology.

1. Introduction

Among the numerous factors impacting command and control, the environment is one of the primary ones. Nearly all facets of C2 are effected (logistics, Intelligence, Surveillance and Reconnaissance (ISR), aviation, and maneuver to name several). Impacts include failed missions, inefficient use of resources, and even unnecessary casualties. By providing environmental effects decision aids (to include effects on threat operations and systems) that are

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eventually fully integrated into all C2 applications, C2 planning and execution can use the environment as a force multiplier.

2. **Products and Approach**

In the 1980's, the military first began to utilize personal computers for the automation of certain C2 functions (e.g., Nuclear, Biological and Chemical [NBC] warning message preparation). However, for the most part, these applications resided on stand-alone systems that could not communicate with other C2 systems. As a result these C2 computer systems could neither automate the entry of the data that may have been required from another battlefield functional area (BFA) (e.g., weather data for NBC report preparation) nor could it pass this information along to other systems. Instead, manual entry of this data was performed after receiving it from h the other BFA system operator(s). The product created from this manual data entry was then physically passed to the other operators ("sneaker net"). Time may have been saved in the automated preparation of the report (once all data was manually retrieved and entered), however, seamless integration with other C2 systems was not possible.

Realizing this shortcoming and leveraging the advances in computer and communication technology, the 1990s saw a proliferation of networked C2 systems that automate the sharing of battlefield information. The ABCS connects numerous workstations (via a local area network) that cover the BFAs of maneuver, intelligence, field artillery, logistics, and air and missile defense. The Integrated Meteorological System (IMETS) is the Army's tactical command and control system for weather and resides as a subordinate system of the intelligence BFA. IMETS provides weather data and weather effects to the various other BFAs as well as to the IMETS operator, an Air Force Staff Weather Officer (SWO). The Army Research Laboratory (ARL) has developed an Integrated Weather Effects Decision Aid (IWEDA) [Sauter, 2000] which is being transitioned to the fielded Army via integration with all BFAs. IWEDA processes high resolution (10 km horizontal) mesoscale model output into weather effects information for graphic and text display and allows the user to display as much or little information about impacts as required. Figure 1 shows a weather effects matrix (WEM) over a 72 hour forecast period for several of the available weapon systems or operations (a total of over 100 are currently in the IWEDA inventory to include 16 threat items). WEM matrix cells are color-coded with red indicating an unfavorable environmental impact, amber a marginal impact, and green no impact. IWEDA map overlays are integrated onto the Common Tactical Picture (CTP) which can be toggled on or off along with other BFA overlay information by the various BFA operators. Figure 2 shows the spatial distribution of weather impacts for a specific weapon system overlaid on a map background. The user can view a detailed listing of the weather impact(s) by left clicking anywhere on the map background to retrieve the text statements (see lower left portion of figure 2). Raw gridded weather data has been furnished to other BFAs in a semi-automated fashion to support vehicle mobility models and NBC hazard warning production.
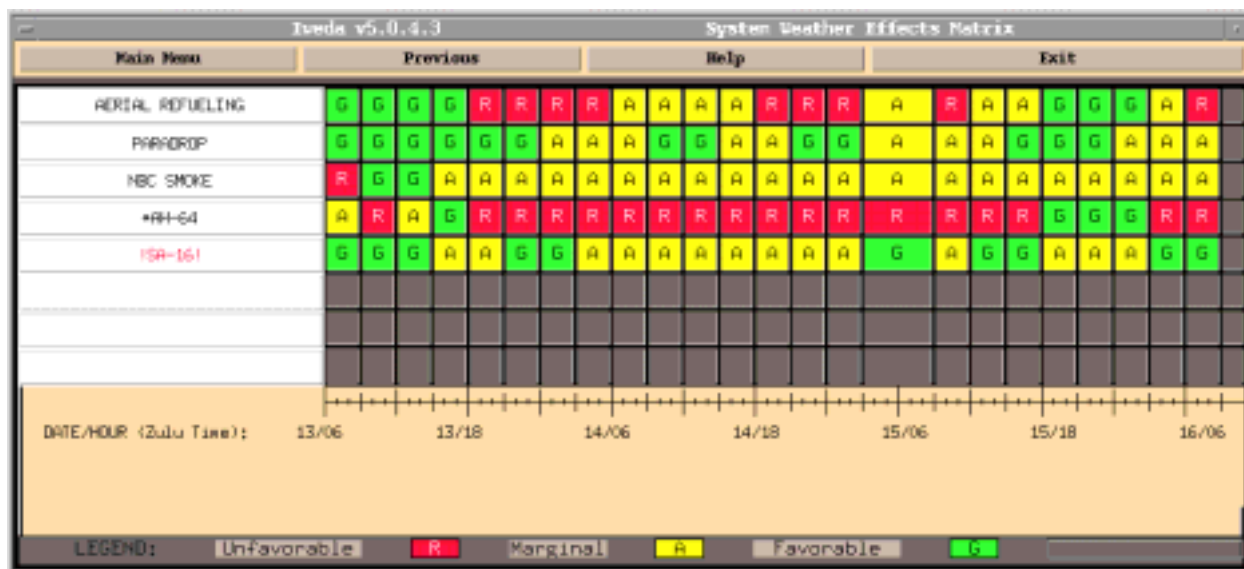
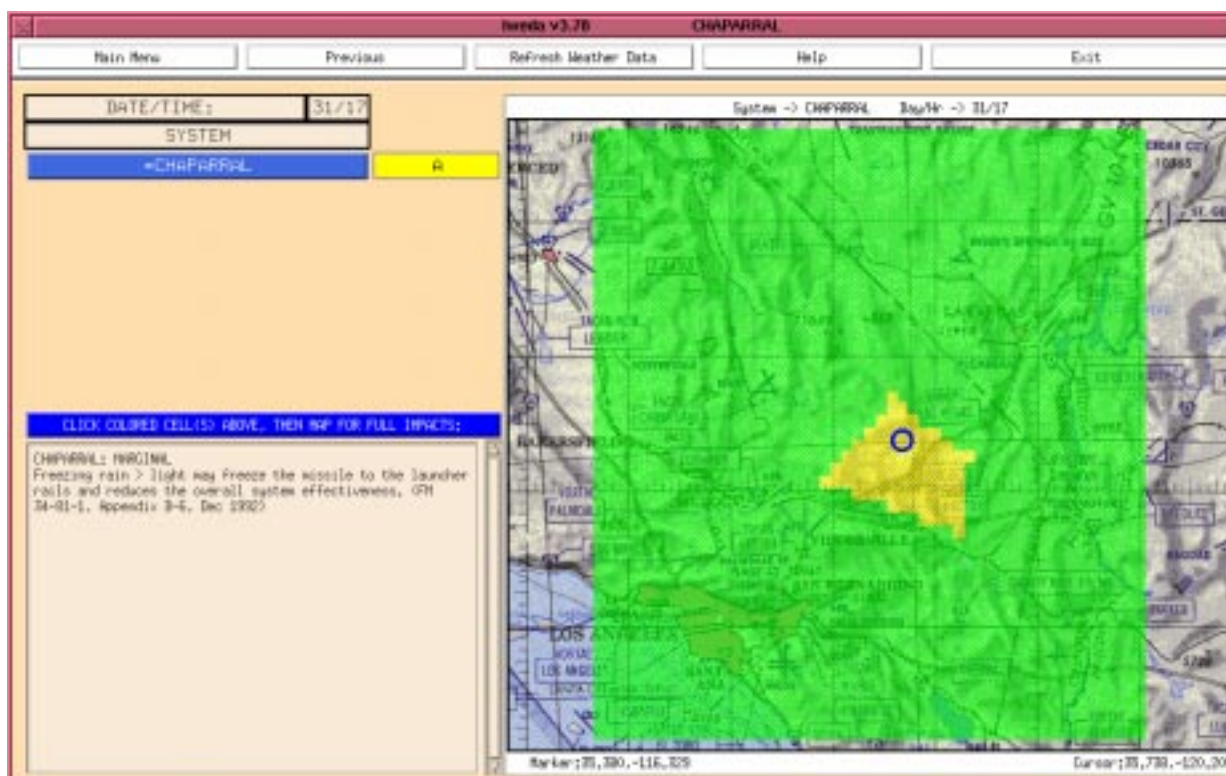Figure 1 – 72 hour IWEDA Weather Effects Matrix (WEM)

Figure 2 – Spatial distribution of impacts on Chaparral

In addition to the IWEDA application that runs in a client-server distributed computing environment, there are a number of other tactical decision (TDA) software products resident on the IMETS that provide environmental data or effects data for the SWO. Some of these products include:

- A heat stress decision aid that computes wet bulb globe temperature, number of canteens of water required to sustain activity, probability of heat stress injury, maximum work times, and work/rest cycle times (the last 4 parameters as a function of work and clothing level). [Pandolf et al., 1986]

- A target acquisition program that computes detection and recognition ranges for a number of sensor types (e.g., thermal imagers, image intensifiers, direct view optics, and silicon televisions) and targets as a function of the environmental conditions. Ongoing efforts will integrate this algorithm directly into IWEDA for seamless computation and display of results within the weather effects application [Sauter and Shirkey, 1999]. This will allow for the display of both qualitative and quantitative effects information within a single application.

- An illumination routine that calculates the ambient illumination levels at the earth's surface as a function of three-layer fractional cloud cover, surface albedo, and precipitation. This routine first determines the solar and lunar positions in the sky (and lunar phase) for a given location and date/time. The resultant illumination parameter can then be used by other TDAs as input and includes a night vision goggle (NVG) algorithm that provides guidance on favorable, marginal, and unfavorable times for NVG use by pilots or troops. [Sauter and Zertuche, 1994]

- An IWEDA rule editor that allows for the modification or deletion of existing default critical thresholds for individual systems or operations. [Torres, 1997]. This provides the SWO with flexibility in the field to tailor rules to the tactical situation at hand.

- A contouring routine to view any of the environmental parameters as computed by the prognostic mesoscale meteorological models. Line contours, shaded contours, and wind streamlines can all be plotted over a realistic map background to give the user an idea of the spatial variation of the parameter(s).

IWEDA has applications other than associated solely with the tactical environment as evidenced by the following efforts:

- By feeding IWEDA climatological data as opposed to 2-3 day forecast data, long range planning can be used to possibly determine optimal tactics and weapon systems to use over various locations and times of the year well in advance of any potential conflicts. ARL has assisted the Air Force and Argonne National Laboratory in the development of such a prototype [Hummel et.al, 2000].

- The IWEDA critical thresholds database has been provided to the wargaming and modeling and simulation communities. In turn, the existing ruleset was used to assign numeric

penalty values to military operations and weapon systems such that weather effects can be more accurately incorporated (or incorporated at all).

3. **Future Thrusts**

Although applications such as IWEDA have been successful in providing environmental effects information to all BFAs, the tactical user would normally prefer to see this information integrated into his existing or developing applications as opposed to opening a separate program. In response to this requirement, an effort is underway to integrate IWEDA information into the Maneuver Synchronization Matrix. This matrix currently displays a timeline of critical missions and operations for various Army units but does not include environmental effects. As stated initially, environmental effects can potentially have adverse impacts on most aspects of C2, thus it is critical to incorporate them in the planning and execution phases. Requiring the user to open a separate application (IWEDA) to view these effects may interfere with the ongoing analysis and interpretation of an existing process and may not be performed if the time cycle is short. Integrating IWEDA information into this matrix by automatically reading the systems and operations associated with the matrix and then providing an "Environmental Effects" button on the matrix will allow for the seamless integration. A second effort involves the design and coding of an environmental effects intelligent agent. This agent would allow for the background monitoring of missions and systems (either manually entered or automatically read from a database) based on evolving weather forecasts as produced on the IMETS. An audible and/or visible alarm would sound and/or be displayed if there are adverse impacts on monitored items.

Unfortunately, as computer hardware and software capabilities advance, they may do so in a manner that makes prior work incompatible with the emerging paradigm. As an example, in order to downsize hardware requirements for lower echelons within the Army, many units are utilizing laptop computers based on the Microsoft NT Operating System as opposed to the Solaris Operating System. This necessitates the extensive rewrite of the graphical user interface from one based on Motif/XWindows to the MS Windows environment. With a large number of software applications, this becomes a time consuming project. As a result, efforts were recently initiated at the ARL to rewrite all of our applications in Java. This will provide a common look and feel of the interface between platforms and also allow for platform independence. IWEDA was chosen as the initial test application to be rewritten under Java. Results have been encouraging.

With the advent of multinational campaigns and increased emphasis on joint service (i.e., Army, Navy, and Air Force) exercises it is also imperative that these environmental effects modules merge into a common suite of applications. Failing to do so will not only waste valuable resources in the development of similar programs but also result in confusion and potentially conflicting results during these campaigns and exercises. In order to avoid this scenario, ARL has marketed the IWEDA software to the Navy and Air Force within the U.S. Department of Defense with positive results. Both the Navy and Air Force have provided funding support to transition the IWEDA technology to their command and control systems. As a result, the Navy will:

- Demonstrate IWEDA onboard the USS Coronado in a multi national cooperative Navy exercise in June 2000

- Participate in the Joint Warfare Interoperability Demonstration with IWEDA at the Norfolk and San Diego sites in June/July 2000

- Showcase IWEDA at the U.S. Naval War College for GLOBAL 2000 in August 2000 (wargaming exercise)

- Incorporate IWEDA into their tactical command and control software system (NITES - Navy Integrated Tactical Environmental Subsystem) in the summer of 2000

The Air Force will also be demonstrating the IWEDA capability during their Joint Expeditionary Force Exercise (JEFX) in August/September 2000. This exercise will feature IWEDA as a stand alone application as well as a module that can be run from a web browser (both as provided by ARL). The Army, as stated earlier, has already fielded IWEDA as part of the IMETS suite of applications, and utilizes IWEDA as the common environmental effects application for the remaining BFA C2 systems. Most recently, IWEDA was demonstrated to NATO members in the hope that this technology can eventually be transitioned to those countries.

As computer and communications technology continues to develop and BFA applications evolve to leverage this technology, additional opportunities for integrating environmental effects information are likely to develop and will be exploited as appropriate. During this decade it may be possible to electronically forward and display critical environmental effects information to the individual soldier on the battlefield (e.g., heat stress or cold strain warnings, NBC hazard dispersion information, etc.). In addition to running the current mesoscale weather models (horizontal grid spacing of kms) it may be possible to run finer scale microscale models (grid spacing of 10's or 100's or meters) on small domains (10's of km on a side) to examine weather and its effects in complex terrain or urban settings.

4. **Summary**

Simply providing a system that ingests and displays or distributes raw weather data for C2 systems is not sufficient in today's tactical battlefield environment. The rapid tempo of the battle and massive amounts of data require integrated BFA systems that can communicate with each other, share data, and even more importantly share *processed information.* IMETS is a first step in providing the infrastructure in terms of hardware and software for allowing the C2 systems to retrieve and utilize weather and weather effects data locally. Additional enhancements will allow for even further integration and automation (e.g., an intelligent agent to monitor weather effects). Java holds promise for eliminating the platform dependence of software applications while coordination between the U.S. Department of Defense services should eventually allow for the development and deployment of a common suite of environmental effects decision aids. An ongoing effort between the U.S. services to design a common Meteorological/Oceanographic Database (METOC DB) will someday allow for not only common applications but also the sharing of information from a common joint database. As evidence of the broad appeal of the

IWEDA module and perhaps an indicator of usefulness for coalition forces, the U.S. National Weather Service has also expressed interest in using the technology for local emergency planning purposes.

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